

REMARKS

Claims 1- 2, 4-24, and 59-63 are pending in the application, of which claims 1, 13, 15 and 20, are being amended, claim 3 is being cancelled, and claims 59-63 are being added.

Claim 1 is being amended to recite a variable voltage supply capable of maintaining the first and second electrodes at a plurality of selectable voltage levels during an ion exchange stage such that each selectable voltage level has a different magnitude and provides a different ion concentration range in the effluent solution. Claim 13 is being amended to recite a variable voltage supply to maintain the first and second electrodes at a plurality of different selectable voltage levels during an ion exchange stage such that each selectable voltage level has a different magnitude and provides a different ion concentration range in the effluent solution. Claim 15 is being amended to recite varying the strength of the time averaged electric field during ion exchange of the influent solution by selecting one of a plurality of selectable voltage levels that each have a different magnitude to control the ion concentration of the effluent solution. The claim amendments are supported at least by original claim 3 which is now being canceled, and the Specification at page 14, lines 22 to 25.

Claim 20 is being amended to add a "period" at the end of the claim.

Claims 21-58 are being canceled without prejudice or disclaimer. These claims will be presented in divisional applications.

Claims 59-63 are being added and these new claims are supported at least by original claims 15-20, and the Specification at page 14, lines 22 to 25.

Entry of the claim amendments is respectfully requested because the claim amendments and added claims are fully supported by the Specification and add no new matter.

Claim Rejections under 35 U.S.C. § 103(a)

Claims 1-20 were rejected under 35 U.S.C. § 103(a) as being unpatentable over Nyberg (USPN 5,788,826) in view of Tessier (USPN 5,762,774).

Applicant respectfully traverses this rejection because the combination of Nyberg and Tessier do not teach or suggest the presently claimed invention. One of ordinary skill in the art would not be motivated to apply the teachings of Tessier to the cell taught by Nyberg because Tessier teaches a different apparatus to achieve a different result than the apparatus taught by Nyberg.

Claim 1 is to a solution treating apparatus comprising, *inter alia*, an electrochemical cell comprising a housing with electrodes, a water-splitting ion exchange membrane which has both cation and anion exchange surfaces and a solution channel that allows influent solution to pass both the anion and cation exchange surfaces. Claim 1 further recites a variable voltage supply capable of maintaining the first and second electrodes at a plurality of selectable voltage levels during an ion exchange stage such that each selectable voltage level has a different magnitude and provides a different ion concentration range in the effluent solution.

As acknowledged by the Examiner, Nyberg "does not disclose that the voltage is controlled based upon the amount of the ions or the use of a variable voltage supply as claimed." Applicant agrees that Nyberg does not teach a variable voltage supply capable of maintaining the first and second electrodes at a plurality of selectable voltage levels during an ion exchange stage such that each selectable voltage level has a different magnitude and provides a different ion concentration range in the effluent solution.

However, the Examiner continues to cite Tessier "to show that such control of the voltage based upon the ionic conductivity of the fluid is used in the art to purify liquids...".

Applicant respectfully suggests that the combination of Tessier and Nyberg does not provide a *prima facie* obviousness rejection because Tessier does not teach the same type of electrochemical cell as that taught by Nyberg. The voltage control taught by Tessier is provided for the particular type of electrochemical cell and membrane taught by Tessier which is a different electrochemical cell than the one taught by Nyberg. For example, claim 1 is to an electrochemical cell comprising a water-splitting ion exchange membrane having a cation exchange surface and an anion exchange surface. As claimed, the same membrane structure has both a cation exchange surface and an anion exchange surface, and the interface between the anion and cation surfaces, forms a water-splitting interface. The water-splitting membrane splits water only because the anion and cation exchange surfaces directly contact each other within a single membrane. The claimed cell, which is derived from the cell taught by Nyberg, relies on the combination of the anion and cation exchange resins in a single membrane to split water, to operate the electrochemical mechanism.

In contrast, Tessier teaches an electrochemical cell comprising separate anion and cation membranes, and in the Tessier cell, the cation exchange resin and the anion exchange resin do not directly contact one other, and consequently, do not form a water splitting membrane. Tessier teaches "alternating arrangements of cation permeable membranes and anion permeable membranes defining compartments therebetween." (Column 1, lines 31-35). In other words, Tessier teaches an electrochemical cell in which the cation and anion exchange materials (or membranes) are each positioned in separate deionization and concentration compartments, with the deionization compartments comprising either anion or cation exchange material, and the cation and anion exchange materials do not contact or touch each other at an interface. Thus Tessier does not teach an electrochemical cell comprising a water splitting membrane having a single membrane with both a cation exchange surface and an anion exchange surface, and with an interface therebetween that serves as a water-splitting interface. The separate anion and cation membranes suspended in separate cells, as taught by Tessier, do not have a common interface, and as such, do not split water. Thus, Tessier teaches application of voltage control to a different type of the cell, which does not operate the same way as the present

cell, and thus, the two references should not be combined.

Further, as claimed, the present electrochemical cell has a solution channel which allows "the influent solution to flow past both the anion and cation exchange surfaces of the water-splitting ion exchange membrane and thereby form the effluent solution." [Emphasis added]. In contrast, Tessier teaches separate compartments, as Tessier teaches "[i]n use, liquid to be deionized is passed through the diluting compartments and the "waste" liquid is passed through the concentrating compartments." (Column 1, lines 45-47). Tessier also teaches separate solution channels, one solution channel passing next to the cation exchange membrane, and a separate and distinct solution channel that passes next to the anion exchange membrane. Consequently, Tessier does not teach an electrochemical cell having a single solution channel that passes fluid across both the anion and cation exchange surfaces, as claimed.

Thus Tessier is directed to a different type of electrochemical cell than the cell taught by Nyberg. Consequently, the teachings to a voltage supply as taught by Tessier should not be combined with water splitting cell taught by Nyberg, as these are two different types of electrochemical cells, operating with different mechanisms.

In addition, Tessier is deficient because Tessier does not teach the voltage supply claimed. Tessier does not teach a variable voltage supply capable of maintaining the first and second electrodes at a plurality of selectable voltage levels during an ion exchange stage such that each selectable voltage level has a different magnitude and provides a different ion concentration range in the effluent solution. Tessier also does not teach a variable voltage supply which, in operation, provides selectable voltage levels that may be selected by a user during electrochemical deionization, to provide different ion concentration ranges in the resultant effluent of the solution passing through the cell.

Instead, Tessier teaches away from the claimed voltage supply by teaching selection of a single optimized voltage level, as determined by an "E-Factor" applied to the cell. Tessier teaches that "[t]he present inventors have determined that operation of an

EDI apparatus can be controlled in accordance with a ratio, referred to by the present inventors as an "E-factor", or Ef, which is defined by" an equation. (Emphasis added, column 6, lines 47-55). By teaching the desirability of a singular optimized "E-factor" value, Tessier teaches away from the claimed variable voltage supply that provides a plurality of selectable voltage levels during an ion exchange stage that have a different magnitude and provide a different ion concentration range in the effluent solution, as claimed.

Furthermore, the combination of Tessier and Nyberg does not teach or suggest claim 1 because the cited references, even if combined, would not result in the claimed invention. Specifically, applying a variable voltage supply as taught by Tessier to the types of electrochemical cells taught by Tessier would not achieve the results obtained from the claimed apparatus, as the cells taught by Tessier do not have the same structure or operate in the same manner. Specifically, the Tessier electrochemical cell does not have a water-splitting membrane which has both a cation and an anion exchange surface in contact. The present electrochemical cell and water-splitting membrane allows, for example, a User to select a particular taste of drinking water when an influent solution of water is passed through the electrochemical cell. This is because both the anions and the cation exchange rates are controlled by adjusting the voltage supply to a selected level in the claimed electrochemical cell. In contrast, Tessier teaches applying a voltage to obtain a particular ion concentration in only the deionization channel, which is either the anion exchange compartment or the cation exchange compartment, but not both.

As explained in the Specification, Applicant's composite membrane and the single solution channel which passes fluid across the interface of the claimed membrane, allowing the electrical current passed through the solution to split water and allow cations and anions to be exchanged within the single solution channel passing through the housing. As explained in the Specification:

At the interface between the cation and anion exchange layers **51, 49** of the water-splitting ion exchange membranes **100**, water in the solution stream is split into its component ions H^+ and OH^- , and OH^- migrates through the cation

exchange surfaces **48** toward the first (positive) electrode **40** while H^+ migrates through the anion exchange surfaces **46** toward the second (negative) electrode **45**. In this step, Na^+ diffuses and migrates through the cation exchange surfaces **48** in the direction of the negative electrode. The reactions occurring in the cation exchange layers **51** are:

- (1) $P-SO_3H + Na^+ = P-SO_3Na + H^+$
- (2) $H^+ + OH^- = H_2O$

where "P" refers to the polymer or solid support to which the ion exchange group is attached. The OH^- produced by the water-splitting reaction and migrating through the cation exchange surfaces **48** reacts with H^+ to form water. The consumption of H^+ maintains the electric and concentration gradients which promote the rate of removal of Na^+ from solution.

Within the anion exchange layer **49**, Cl^- diffuses and migrates through the anion exchange layer **49** in the direction of the positive electrode. The reactions occurring in the anion exchange layers **49** are:

- (3) $P-NR_3OH + Cl^- = P-NR_3Cl + OH^-$
- (4) $H^+ + OH^- = H_2O$

Analogous to the situation in the cation exchange layer **51**, the H^+ produced by the water-splitting reaction reacts with OH^- to promote the rate of removal of Cl^- from solution. (Specification, page 11, line 17 to page 12 line 4).

Without this water-splitting effect generated by a membrane having both anion and cation exchange surfaces, and a single solution channel that passes across both of these surfaces, the electrochemical cell taught by Tessier would not control the both the anion and cation concentration range in the effluent solution to achieve predefined values using a variable voltage supply capable of maintaining a plurality of selectable voltage levels having different magnitudes across the first and second electrodes during an ion exchange stage.

For these reasons, the combination of Nyberg and Tessier do not teach or suggest claim 1.

Claim 15:

The combination of Nyberg and Tessier also do not teach or suggest claim 13 because the cited references do not teach an apparatus comprising, *inter alia*, an electrochemical cell comprising a water-splitting ion exchange membrane positioned between first and second electrodes, the membrane comprising (i) a cation exchange surface facing the first electrode, and (ii) an anion exchange surface facing the second electrode; and a variable voltage supply to maintain the first and second electrodes at a plurality of different selectable voltage levels during an ion exchange stage such that each selectable voltage level has a different magnitude and provides a different ion concentration range in the effluent solution.

The combination of Nyberg and Tessier also do not teach or suggest claim 15 because the cited references do not teach a method of treating an influent solution comprising, flowing the influent solution past both anion and cation exchange surfaces of a water-splitting ion exchange membrane to form the effluent solution, maintaining a time averaged electric field across the cation and anion exchange surfaces of the water-splitting membrane, and varying the strength of the time averaged electric field during ion exchange of the influent solution by selecting one of a plurality of selectable voltage levels that each have a different magnitude to control the ion concentration of the effluent solution.

As acknowledged by the Examiner, Nyberg does not teach varying the strength of the time averaged electric field during ion exchange of the influent solution by selecting one of a plurality of selectable voltage levels that each have a different magnitude to control the ion concentration of the effluent solution.

Tessier does not make up for the deficiencies of Nyberg because Tessier does not teach or suggest flowing the influent solution past both anion and cation exchange surfaces of a water-splitting ion exchange membrane to form the effluent solution as claimed. As explained above, Tessier does not teach a water-splitting ion

exchange membrane and instead teaches a cell having a different membrane structure. Thus, Tessier cannot be teaching the step of maintaining a time averaged electric field across the cation and anion exchange surfaces of a water-splitting membrane as claimed.

Further, as explained herein, applying the voltage supply of Tessier to the cell of Nyberg would not result in the “varying the strength of the time averaged electric field during ion exchange of the influent solution by selecting one of a plurality of selectable voltage levels that each have a different magnitude to control the ion concentration of the effluent solution.” In effect, Tessier et al. teaches against applying voltage levels that each have a different magnitude to control the ion concentration of the effluent solution, by teaching that a single optimized voltage is most effective for a particular ion concentration in the solution being treated.

For these reasons, Nyberg and Tessier do not teach or suggest method claim 15.

Claim 59:

The combination of Nyberg and Tessier also do not teach or suggest added claim 59 because the cited references do not teach a method of treating an influent solution comprising anions and cations, flowing the influent solution past both anion and cation exchange surfaces of a water-splitting ion exchange membrane to form the effluent solution, maintaining a time averaged electric field across the cation and anion exchange surfaces of the water-splitting membrane, and setting the strength of the time averaged electric field during ion exchange of the influent solution by selecting one of a plurality of selectable voltage levels that each have different magnitude and provide a different ion concentration range in the effluent solution.

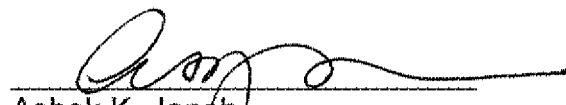
Should the Examiner have any questions regarding the above amendments or remarks, the Examiner is requested to telephone Applicant's representative at the number listed below.

Respectfully submitted,

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